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"I gave my son directions to show you two other coins of the same set, which you possibly will also reckon Etruscan.

"I am, dear Sir William,
"Your faithful Servant,
"THOMAS L. COOKE."

The following notice was communicated by Sir William Rowan Hamilton, of a Paper "on the Application of Quaternions to the Determination of the Distance of any recently discovered Comet or Planet from the Earth."

This celebrated problem is treated in this paper by means of the formulæ which were communicated to the Academy by the author, in July, 1845. The chief step consists in a very easy deduction, from those formulæ, of the equation:

$$\frac{a}{c}\left(\frac{M}{a^3}-\frac{M}{b^3}\right)=\frac{S.\gamma\gamma'\gamma''}{S.\gamma\gamma' a};$$

where c is the sought distance of the comet (or planet) from the earth; M is the mass of the sun, and a and b are the distances of earth and comet from that body; a is the heliocentric vector-unit of the earth, and γ is the geocentric vector-unit of the comet; while γ', γ'' are the first and second differential coefficients of γ, taken with respect to the time, and determined, along with γ itself, from three successive observations: and S is the characteristic of the operation of taking the scalar part of a quaternion. The second member of the equation admits of being geometrically interpreted as a ratio of two pyramids, and can in various ways be transformed by the rules of the calculus of quaternions.

Mr. Donovan exhibited a table gas lamp of his invention, which generates its own gas, and made the following statement relative to it:

" Previously to describing my inventions, for some of which I obtained patents for the three kingdoms and colonies, it will be necessary to make some observations on the nature of those substances which are concerned in the production of economical light.

" Every one knows that, although hydrogen is a chief combustible element in all those flames which are used for the purpose of illumination, its own flame, when the gas is perfectly pure, shows no light. In order to render it luminous we have only to diffuse through it a small quantity of one or other of the different forms of carbon or charcoal in a state of very minute division. All our ordinary lights are derived from combinations of hydrogen and carbon; such are coal gas, oil gas, resin gas, coal naphtha; or from combinations of hydrogen, carbon, and oxygen, as oil, tallow, wax, spermaceti, stearine of various kinds.

" If the ratio of carbon to hydrogen be too small, the light emitted from the combustible in burning will be pale and feeble; if the ratio of carbon be too large, the flame will be yellow, or even brown and smoky. It is to the due adaptation of the ratio of these two elements to the supply of oxygen, whether contained in the combustible or in the air, that we owe the production of the many brilliant lights which we possess.

" But the carbon and hydrogen need not be in that state of combination in which we procure them. A hydrogen flame may be rendered intensely luminous by the artificial supply of carbonaceous matter; and a flame which is too pale and feeble, such as that of hydrogen, bad coal gas, or of the oil or stearine from the cocoa-nut, may be enriched to the greatest intensity by merely presenting carbon in a proper state. Carbon in such a state exists in all the volatile hydro-carbons, as mineral naphtha, naphthaline, naphtha from coal tar, from oil, from resin, or from Indian rubber; it exists also in essential oils, and in spirit of turpentine or of resin, or of tar.

" It was upon a knowledge of these facts that I founded the inventions for which I obtained patents. My first efforts were directed to the diffusion of the vapour of coal naphtha through hydrogen gas; and to effect this object with economy and brilliancy of the resulting light, I contrived a variety of instruments.

" In the specification of my patents I minutely described some of these; a brief account of one will here suffice, as the details now constitute one of the public records. Into this instrument, which is in the form of a lamp, a stream of hydrogen is passed, and dispersed by a tube having many small holes into a small cylinder, also pierced with holes, and round which a piece of iron wire-gauze is rolled. This wire-gauze roll is continually kept wetted, either with one of the less volatile kinds of coal naphtha, or with naphtha obtained from resin or from Indian rubber, or with spirit of turpentine, or fine spirit of tar, or other volatile hydro-carbon. The hydrogen passes out through the holes of the burner of the lamp, and, being kindled, generates much heat, which, being quickly transmitted downwards to the wire-gauze, heats the volatile hydro-carbon with which it is constantly impregnated, and converts it into vapour. The vapour mixes with the hydrogen, and the mixture is now much of the same nature as coal gas, or oil gas, or resin gas; it burns with great brilliancy, provided that the parts of the lamp bear a proper proportion to each other.

" The office of the roll of iron gauze is to raise the hydro-carbon by capillary attraction through its meshes and convolutions, and thus to present the hydro-carbon on extensive surfaces to the solvent power of the hydrogen which continually passes through.

" In my early experiments I had found that the less volatile hydro-carbons did not diffuse their vapour through hydrogen at ordinary temperatures, and hence it was necessary to maintain an elevated degree by the application of foreign heat. It was an important improvement to contrive the apparatus in such a manner that the hydro-carbon should be constantly maintained at an adequate temperature by the proximity of its own combustion. This was at last effected by very much shortening the burner and gas-ways, and connecting the brass tube which held the wire-gauze with the burner, so that the heat of the flame was transmitted directly downwards, by conduction, to the wire-gauze and hydro-carbon.

" Hydrogen, as obtained by the processes of the laboratory, is exceedingly expensive; it therefore became necessary to ascertain whether I might substitute for it that very light carbureted hydrogen which is procured by passing the steam of water over charcoal or coke, maintained at a bright red heat in an iron retort. This gas contains so little carbon, that, for practical purposes, it may be considered as hydrogen; and it was essential to know whether, when used in the above-mentioned manner, it would create a sufficiency of heat to volatilize the hydro-carbon.

" In order to ascertain this and other important particulars, I caused an iron gas retort of the ordinary kind, with a well ground mouth-piece, to be built into a furnace erected for that purpose. The retort was capable of containing two pounds of Newcastle coke; it was furnished with a tube and stopcock at one end for the admission of steam: and a tube at the other end for carrying off the gas generated by the decomposition of the water into a gasometer containing milk of lime.

" When the retort was maintained at a bright red heat, and the steam let on, gas was generated in such torrents that at one time I feared some untoward result. By calculation from this experiment I found that to furnish 1000 cubic feet of gas 16·8 avoirdupois pounds of coke should disappear. The interior of the iron retort had been previously protoxidized, to prevent, as much as possible, its contributing to the produce tion of hydrogen. But I found that, although the scale of protoxide is exceedingly hard, it does not protect the interior of the iron; the process of destruction is slow but certain. Earthen gas retorts, such as were patented several years since by Mr. Grafton, would perhaps answer better.

"On making a trial of this, which has been called water gas, I found that, notwithstanding the presence of much carbonic oxide, it gave off quite a sufficiency of heat, when burned in my different lamps, to volatilize the hydro-carbon, and to afford a brilliant light: by itself it burns blue.

"The various volatile combustible liquids already mentioned are applicable to the foregoing purposes with different degrees of efficacy. Those that require high temperatures for their volatilization are the fittest, because the source of heat is so near the wire-gauze that the vaporization easily takes place.

"But there are hydro-carbons which, being volatilized at the ordinary temperature of the air, afford much more manageable means of rendering hydrogen gas luminous in burning. Of these, by far the most convenient and economical are the finer kinds of coal naphtha. It is obtained by the distillation of coal tar, and is procurable in various degrees of purity in commerce. Coal tar is an article of very small price, and when deprived of its naphtha, instead of being depreciated in value, it is enhanced. By several rectifications the naphtha becomes pure and colourless, and very volatile. Its quality varies materially according to the coal used at the gas works from which the tar was obtained. The greater the specific gravity, provided it is pure, the greater is its volatility. The purest and heaviest naphtha that I have been ever able to obtain from Newcastle coal tar, was s. G. 0·888: this was the result of repeated rectifications, the first products only, in every case, being retained. This naphtha began to boil at 166°, but boiled rapidly at 172°. The purest and heaviest naphtha, from Scotch Parrot coal tar, that I could procure by any number of rectifications, was s. G. 0·862°; it began to boil at 183°, and boiled rapidly at 189°. None of these naphthas have a fixed boiling-point. In all cases the heaviest and most volatile portions come over first in distillation, and are the most valuable for the purposes here described. No dependence is to be placed on high specific gravity as a test of fitness: the naphtha may be heavy on account of the presence of tar and naphthaline, and in this state it will not answer the purpose. When the naphtha is colourless, heavy, and vaporizable from a flat open vessel, without leaving any residuum or stain, it is of the best quality.

" During the destructive distillation of common resin, a naphtha is obtained which, by proper rectification, becomes as pale as water, and succeeds admirably for the purposes here described. Indian rubber affords a naphtha of s. g. 0·820, or even 0·680; in which last state it boils at 98°, and answers perfectly.

" The ratio of hydro-carbon necessary for rendering a certain quantity of water gas luminous in burning, will depend on the nature of the former. On this subject I made many experiments. In one of them I found that two equal burners, one supplied from a gasometer containing coal gas, the other from a gasometer containing water gas, which was naphthalized with Newcastle coal tar naphtha before it reached the burner, afforded flames which in equal times emitted equal light when the naphtha was consumed at the rate of one imperial gallon dissolved in 1000 cubic feet of water gas. It was also found that the consumption of coal gas was the same as that of water gas in equal times, the latter having the addition already mentioned; and although the light in each case was equal, as evidenced by Rumford's photometer, the water gas flame was but half the volume of that from coal gas; and therefore the intensity or illuminating power of the former was double. This comparison only holds when the rate of consumption is five cubic feet per hour; when less, the light from a naphthalized water gas flame is more than double the light of an equal volume of coal gas flame. If it be desirable that the illuminating power of naphthalized water gas shall be at its *maximum*, the ratio must be ten and a half imperial pints to 1000 cubic feet of gas. Any higher ratio only impairs the light. When spirit of turpentine is used with water gas, the ratio should be one imperial gallon to 1000 cubic feet.

" The more pure and volatile kinds of naphtha are extremely valuable, from the circumstance of their being easily soluble in hydrogen, or in water gas, at ordinary temperatures. We have only to present extensive surfaces of the naphtha to a current of water gas ; the result will be that the gas will dissolve a quantity of naphtha, and will hold it dissolved even at the temperature of 32°. The mixture of gas and naphtha vapour may be transmitted through tubes in the manner of ordinary coal gas, and burned in the usual way ; its light is white and beautiful. I have described an instrument for producing this gas in the specification of my patent for Scotland.

" I ascertained that when carbonic oxide is naphthalized, its combustion affords a light of brilliant whiteness, although its natural colour in burning is blue.

" Since it was thus proved that hydrogen containing a very small quantity of carbon was capable of dissolving naphtha, it became a question whether that variety of the same combination called coal gas would exert a similar agency, and thus be rendered capable of burning with increased brilliancy. I therefore arranged two common gas-burners for comparison, one being supplied with mere coal gas, the other with coal gas which was made to pass through an apparatus properly constructed for naphthalizing it. It required but little observation to decide that the naphthalized flame was much more brilliant and dense.

" When this trial was made with a gasometer attached to each burner, and an apparatus for determining the quantity consumed, it appeared, after a few hours' trial, that to produce equality of light from both burners, 5·36 cubic feet of coal gas were equal to three cubic feet of naphthalized coal gas which contained 200 grains of naphtha (s. G. 0·872). Such were the quantities burned per hour. Hence 1000 cubic feet of coal gas would require 6·511 imperial pints of such naphtha dissolved in it, in order to give a light which, in illuminating power, would be to that of mere coal gas as 25 to 14.

" I ascertained that the gas which is generated so abundantly during the destructive distillation of wood succeeds perfectly for the purpose of illumination, when enriched with the vapour of naphtha or spirit of turpentine. During this distillation two kinds of volatile spirit are produced ; one of them is well known in commerce, it burns with a pale flame like alcohol; the other burns with a smoky yellow flame, highly luminous. The latter, when purified, answers as well as coal naphtha for the purposes here described. Some kinds of wood afford so much as one-third of their weight of inflammable gas. It is obvious how deserving these facts are of consideration in countries where wood is abundant and coal scarce.

" It is, no doubt, in the recollection of many, that some years since attempts were made to introduce gas condensed in iron cylinders into public use, in Dublin and London ; and portable gas companies were formed for the purpose of carrying that object into effect. I need not now enter into the nature of this project or the cause of its failure. I shall only observe that, by simple methods, founded on the principles already described, it would have been very easy to insure success. I have produced beautiful portable gas-lights, which exceeded all others in steadiness and lustre, by introducing bits of zinc, with a little dilute sulphuric acid, into a copper cylinder, in all respects made like those of iron employed by the portable gas companies. Hydrogen was not only generated, but, as there was no escape, it became highly condensed, even to thirty atmospheres. By screwing on the valve a contrivance somewhat resembling the instruments described in the specifications of my patents, containing naphtha, a flame of unusual steadiness and beauty was produced.

" But there is one modification of the invention which far surpasses all the rest in the facility with which it can be carried into profitable effect, and the universality of its application. I shall proceed to describe it.

" As soon as I ascertained that the vapour of naphtha so easily diffuses itself through various gases, it became a question would naphtha comport itself similarly with atmospheric air, and if so, might not naphthalized common air, notwithstanding the presence of so much azote, afford a flame capable of affording a strong illumination ? Experiment proved that the suspicion was well founded. I tried many methods. I found that a mixture of air and naphtha vapour, *in a certain ratio*, would burn with a very white and brilliant flame; that if the ratio of naphtha were too small, the flame was blue and illuminous, like that of carbonic oxide: and that if the ratio were too great, the light was yellow or brown and smoky. The difficulty was to contrive self-acting means adequate to the apportioning of a sufficient quantity, and no more, of naphtha vapour, to the atmospheric air. My first trials were made with a gasometer filled with common air, which air, being passed over extensive surfaces of naphtha, held absorbed in a roll of hempen canvas, instead of wire-gauze, and maintained at a certain degree of heat, dissolved a portion. The naphthalized air being forced through the holes of a burner, and kindled, afforded a blue flame which showed no light, for the naphtha was too far from the heat of the burner to be maintained at a sufficient temperature.

" I next procured an apparatus in which the burner communicated sufficient heat to the naphtha, and thus obtained a white light; but the jet arising from each hole in the burner was distinct, and the cylinder of flame, instead of being continuous, consisted of separate threads of light.

" The cause was obvious, and the defect was attempted to be remedied by procuring instruments in which the issue holes of the burner were very large and close together, and the gas-ways more than adequate to the supply. At length, by repeated trials, an apparatus was obtained which gave an excellent cylinder of dense flame, and the relative dimensions of the parts were thus determined.

" The advantages of this mode of lighting were obvious : an explosion could never take place; and the tubes for conducting the air from the gasometer, instead of being metallic, might be of thick paper. I constructed lights with paper tubing which answered all purposes.

" But a sufficiently large gas-holder is expensive and inconvenient ; I therefore thought of adopting a double-bellows to my paper tubing. I procured double, triple, and quadruple bellows, most perfectly executed by an organ-builder, but could not obtain a blast which supplied the burners equably; the lights rose high and sunk low with every stroke of the feeders; and multiplying the feeders only multiplied the flickerings. At length the object was accomplished by causing a very small double bellows to discharge air into a reservoir bellows of comparatively large dimensions. When the two feeders were worked *at a certain rate*, and then only, the stream of air was equable, and the gas flames did not flicker. In order to insure this certain rate of action to the feeders, as well as to cause the apparatus to be self-acting, a piece of wheel-work machinery became necessary; and I soon succeeded in adapting a train of wheels, which, being actuated by a weight and regulated by a fly, worked a crank that gave the exact motion required for the bellows. This train supplied the lights for several hours, and, when run down, could be wound up without extinguishing the lights, as it was furnished with a maintaining power.

" Conceiving that the perfection of the invention would be to embody it in the form of a table lamp, which should be as portable as any other, I directed my attention to this object. Finding that it was not practicable to enable so small a double bellows to sustain incessant working without being soon worn out, I discarded that plan; and, recollecting the centrifugal bellows as improved by Papin, in which fans revolving eccentrically in a circular tympanum, with a large opening in its centre, were sufficient to create a current of air, I had several such made in succession, and at length ascertained the smallest that would answer the purpose. Papin's construction failed, but by some alterations and additions it succeeded admirably in giving an equal blast. With these fans I connected a very small train of wheel-work, which, after many modifications, imparted to them the exact velocity necessary for supplying the proper ratio of air to the naphtha vapour. This machine, actuated by a mainspring and maintaining power, afforded a constant blast for eight hours; it might then be wound up without stopping the fans or extinguishing the light.

" Many difficulties still arose, such as the necessity of apportioning the diameter of the holes in the burner; the capacity and number of the air passages in the burner; the length of the burner, and its distance from the naphtha; the number and situation of the holes in the tube which distributed the atmospheric air to the naphtha vapour. Various trials surmounted all of them.

" But a chief difficulty was to find a remedy for the consequences of change of temperature in the apartment where the lamp burns. If the temperature be much raised, the lamp will smoke; if it be much lowered, the light will become feeble; but if maintained without much change of temperature, the light will not alter. Several methods were tried; such as cooling or heating the naphtha by increased or diminished speed of the fans; removing the supply of naphtha farther from, or bringing it nearer to the source of heat, and other minor expedients; but none of them acted satisfactorily.

" A method was then adopted which proved successful. In this lamp, the current of air impelled by the fans had been made to pass over the naphtha in hundreds of streams before it could arrive at the burner. By allowing a sufficient quantity of common air to mix with the naphthalized air, as it passed into the chambers of the burner, a degree of dilution would be produced that would cause the mixture to burn with a pure white light.

"On constructing the lamp with various valves to effect this object, I found that, unless the common air intended for dilution were allowed to mix with the naphthalized air in several streams, the common air would take a direction through one or other of the gas-ways of the burner, and the resulting flame would be yellow in one part, blue in another, and white in a third. By passing the common air in a number of streams a perfect commixture was effected; and by means of a lever outside of the lamp I was enabled to increase or lessen the tenuity of the streams, so that the body of the flame at the burner might be rendered less or more dense, or changed to a flame that should show no light, or to a smoky one. Perfect control was thus established.

"I have found by experiments conducted on a very large scale, that one hundred gallons of naphtha, of S. G. 0·846, distilled from Parrot coal tar, are, in burning with common air, equal, in the light produced, to 122 gallons of the best spermaceti oil. The comparison was made with Argand lamps and lamps of my construction, both showing the same diameter of flame. Other experiments made on a small scale, with photometers of different kinds, gave results a little different. In one trial 100 measures of naphtha equalled 120 of oil; in a second 128 of oil; in a third 130. Assuming 125 to be the number, and taking naphtha at 3*s.* 6*d.* per gallon, and spermaceti oil at double that sum, the oil lights will be two and a half times more expensive than the naphtha lights.

"I made photometrical experiments on the comparison of my lights with common gas lights, the result of which was, that, under proper management, and taking equal volumes of the two flames, my lights had two and a half times the illuminating power of common gas lights.

" Lest any apprehension should exist relative to the consequences of oversetting a lamp containing so inflammable a liquid as naphtha, with a flame burning at the only issue through which naphtha could pass, it is proper to state that the moment any one of the four sides of the lamp is raised half an inch from the table, as in the act of overturning, the lamp spontaneously extinguishes itself. In any case, little naphtha can be spilled; and that little will not leave the slightest stain on the most delicately tinted carpet, or even on silk, as it will dry out perfectly if the naphtha be pure. By another contrivance, the lamp may be moved from place to place without extinction of the flame.

" There is nothing in the construction of the lamp which should render it unmanageable in the hands of a servant of ordinary intelligence. Although even the purest naphtha has a smell equally disagreeable with and resembling common gas, not even the slightest odour can be perceived from it in burning.

" The new table-lamp may be thrown into a variety of shapes, some of them as graceful as any of those now in use, but in that case involving more complication than the one now exhibited.

" It is to be observed that this lamp cannot easily be kindled when the temperature of itself and contents is below 40°. The best mode is to pour in the naphtha immediately before it is required, and then it will kindle at ordinary temperatures, but will show little light for a few minutes; the light will then rapidly increase. If the naphtha contained in its proper supply-can be warmed to 80° or 90° by being placed for some time before the fire, and then poured in, the lamp on being kindled will show excellent light at once."